

## As-Flown Shuttle Micro-Meteoroid Orbital Debris (MMOD) Assessment History

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### Abstract

The final flight of the Space Shuttle program was completed on July 21<sup>st</sup> of 2011. The reusable nature of the Orbiter vehicles has provided NASA with a unique opportunity to inspect and sample spacecraft surfaces exposed to the MMOD environment in low Earth orbit. This paper will provide details of MMOD damages found on Orbiter surfaces after recent flights, as well as putting these damages in context by providing historical comparisons of recent damage to previous flights.

The *Bumper* threat assessment computer code is used by NASA to determine spacecraft MMOD penetration risk. The tool was used before each mission to estimate pre-flight MMOD risk for the Shuttle Program Office using planned vehicles attitudes and exposure times. This paper summarizes the efforts of the authors to assess the expected number MMOD impacts of selected particles sizes of 52 shuttle missions ranging from STS-50 (1992) through STS-133 (2011) using as-flown attitude data. The missions encompass the Shuttle/Mir precursors to the International Space Station (ISS) as well as the ISS assembly flights. The paper includes a comparison of observed MMOD impact damage to the predicted number of impacts from *Bumper* code assessments. This data can be used to validate engineering models of the orbital debris and micrometeoroid environment, such NASA's ORDEM debris model and MEM meteoroid model.